

A review of:
Fluvio-deltaic record of increased sediment transport during the
Middle Eocene Climatic Optimum (MECO), Southern Pyrenees,
Spain

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December 1, 2022

Synopsis

Using two new isotope and stratigraphic sections in the west-central Pyrenees, Cabré et al study the connection between the Middle Eocene Climatic Optimum (MECO) and sediment supply. Working in the Tremp-Jaca Basin, the authors collected geochemical and sedimentological data from two stratigraphic sections. These sections target two separate deltas, which were part of a common depositional system that deepened westward, created by subsidence in the Pyrenees foreland basin. The authors measured stable carbon and oxygen isotopes, trace and major elements, as well as organic matter composition and maturity. They synthesize these data into a new understanding of this basin during the MECO.

Their main findings are supported by two key observations:

1. The authors observe that the MECO coincides with two episodes of delta progradation in this basin. The authors assert that this is due to enhanced sediment supply due to changes in hydroclimate. They reject a suite of alternative hypotheses (enhanced uplifting, eustatic sea level, etc.)
2. The authors observe that patterns in stable isotopes of oxygen from their stratigraphic sections parallel patterns in the global ocean and other basins, patterns of carbon isotopes do not. Based on this observation, they assert that because the deltas are prograding into a restricted ocean basin, the carbon isotope signature is dominated by local effects (provenance, local chemistry) rather than a global input of depleted carbon. It is not made clear why oxygen isotopes are not affected by these processes. The authors assert that diagenesis effects have not altered their samples substantially.

Based on these main findings, the authors conclude that in the Iberian peninsula, climate-induced episodes of enhanced erosion are connected to transient warming and changes in hydroclimate. This bolsters similar findings from strata across the Pyrenees during the Eocene. The MECO is relatively long-lived (~ 500 kyr) compared to its shorter counterpart hyperthermals during the EECO (e.g. PETM (< 200 kyr)). Given this, the authors suggest that the MECO may be a good test case for understanding feedbacks between the carbon cycle, hydrological cycle, and other Earth systems.

Overall Comments

I read this paper with interest, and a fair bit of initial skepticism. The authors have identified a good case study for an important problem. In many stratigraphic studies like this one, there are major issues of resolution and timing. This is particularly a problem with Eocene hyperthermals, where the hypothesized duration of a climate “episode” or “event” is brief enough ($< \sim 100$ kyr) that it can be distorted, disguised, or destroyed entirely by sediment transport processes in the sedimentary basin. On the other hand, if a climate episode is very long (> 1 Myr), then there are few terrestrial basins that can record the full length of the event without major issues of changing subsidence rates and basin filling, etc. This basin, and episode of interest, appears to lie in a kind of optimal middle ground, where the MECO is long-lived enough that

one can be reasonably sure to capture the signal despite transport processes, and yet short enough given the basin size to ignore tectonic issues.

With the aid of this well-chosen field site, the authors have done a really nice job of constraining the problem. By leaning on a firm grounding in regional literature and collecting a comprehensive suite of data, the authors have persuaded me that their model is the most likely scenario. I found the observations to be appropriate, well-reasoned, and well-documented. The analysis of these observations is careful, and clearly articulated.

Overall, I think this is a very well-executed study, it will have substantial appeal to readers of *Climate of the Past* across disciplines. I expect it may spark some increased interest in studying the MECO, and may serve a touchstone for motivating studies that join the best insights of sedimentary geology and paleoclimate. I have a few minor comments and questions for the manuscript, but after those have been addressed, I think it would make a good contribution to CP.

The authors should feel free to reach out to me if they have any questions about my review.

Minor Comments

comments on: Primary vs Diagenetic Signals & MECO isotopic record

I appreciate the value of these two subsections of the discussion. It is important to make sure that your reader is aware that you have rigorously tested the alternative hypothesis. In this case though, I think the order of these two subsections gets in the way of your message. Why have caveats dominate the first part of your discussion? Rather, I would suggest discussing your results (the carbon and oxygen isotopes), identify the discrepancy (the oxygen isotopes match global trends, the carbon do not), then discuss the possible mechanisms. I think by switching sections 5.2 and 5.1 will flow logically better, because it will allow you to place the discussion of your observations first, then follow up with evidence.

Additionally, I found the language in these two particular subsections was less clear than some of the other text in the paper. As a result, I came away with a few points of confusion. For example, I remain confused about why exactly the issues that affect DIC and the carbon isotopes don't affect the oxygen isotopes. It would be helpful to spell this out, and to do some rewriting in these two sections to step through your argument more clearly.

Figure 5, 6, 7, & 10

There are big gaps in the stratigraphic data here. These gaps are mentioned obliquely in line 390, but not clearly laid out in section 3. Why are there such large gaps in sampling? These intervals seem pretty important to the interpretation of your data. Importantly, I don't think you need to have these data to make your point. Rather, I just think the communication is trying to gloss over the missing data. This is happening both in the writing and in the visual communication.

I think a more fair representation of the data completeness is needed. On the written side, would like to see this part of the data explicitly explained somewhere in section 3.1. In the figures, I think that including a dashed line connecting your data in these plots is misleading; it implies a continuity of data you don't have. These connecting lines should be eliminated.

This is especially important in figure 10, which actually does not have dashes. Rather, here, the missing data are represented by a solid, which implies *even more* certainty. This one especially should just have gaps in the record where you have big stratigraphic distances between sampling points.

Age model in Figure 10

It is not made clear how you establish an age model for figure 10. Is it just a linear interpolation based on the cron tie points? This makes some sense, and would be the most complicated procedure your data can justify, but I would like to see it explicitly described somewhere. Or did I miss it?

Typos/Misspellings/Style

I noticed several places where there were copyediting issues. For example: The legend of figure 1 says "Litostratigraphy", not "Lithostratigraphy" These will likely be mostly caught during copyediting, but since this is a quality article already, the authors should take the time this round of edits to go through the thing with a fine-toothed comb.

I also noticed a few instances where the authors could improve their style. For example:

1. "starving" of what? I assume you mean oxygen, but it could mean food as well. line 60

2. You use “key” twice in this sentence, which gives me the impression that you have a whole keyring. Moreover, the actual meat of the sentence is a little vague, and the reader comes away with no concrete idea of what you mean. Rather than declaring that the MECO can teach us something about the Earth system, I would re-write this to just specifically state *what* it can teach us. line 52
3. “suffered” is a strange word here. It applies a bit too much humanity to the oceans, for my taste. line 55
4. The (2.4 My) in parentheses is redundant. line 50

These are a few examples, and I would urge the authors to make sure their language is really good this round of edits, because I think the paper is pretty close.